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## Notes on Eocene and Oligocene Fossil Localities in Inner Mongolia<sup>1</sup>

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During a recent study of Mongolian tapiroids in the collections of the American Museum of Natural History, I encountered a certain amount of confusion in the names given to Eocene and Oligocene fossil-bearing strata and localities in Inner Mongolia. Collections from the same horizon and locality have been called by more than one name, and formation names have been applied to beds far from the type localities, without adequate evidence for correlation. To help clarify this situation, to aid interpretation of past work, and to facilitate future research, I present the following notes. They are based on information obtained from the papers cited below and from the field notebooks of Granger, Morris, and Spock (on file in the Osborn Library at the American Museum of Natural History).

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### IRDIN MANHA REGION

The term "Irdin Manha Formation" was originally proposed by Granger and Berkey (1922, p. 5) for clays, sands, and gravels forming the Irdin Manha escarpment where it is crossed by the Kalgan-Ulan Bator telegraph line and road, about 20 miles south-southeast of Iren Dabasu (now called Erhlien), Inner Mongolia (see fig. 1). The lower

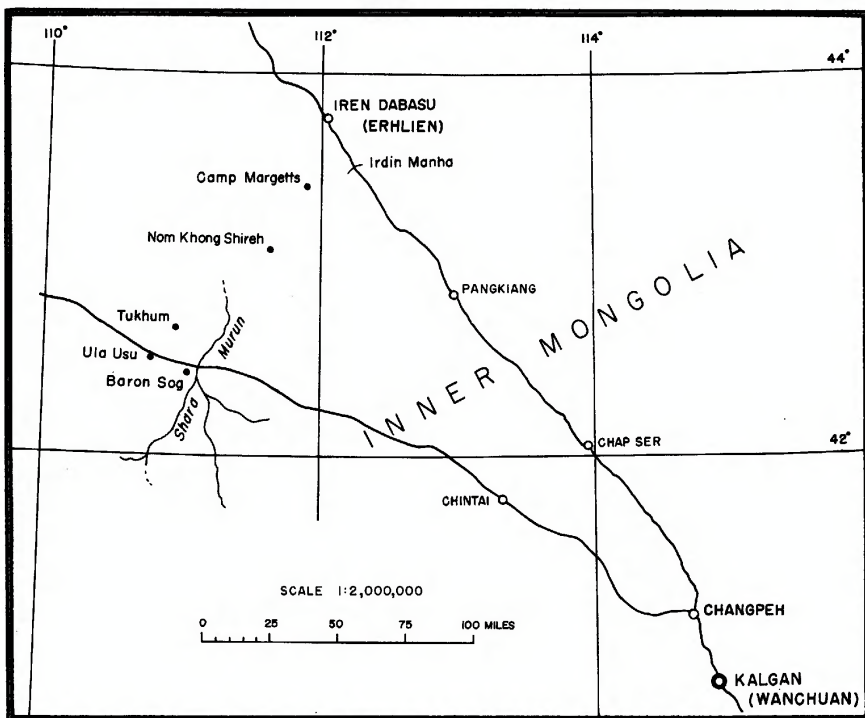


FIG. 1. Map of a portion of Inner Mongolia, showing Eocene and Oligocene collecting localities of the Central Asiatic Expeditions of the American Museum of Natural History.

part of the section, consisting of red clays and fine silts, was later named the Arshanto Formation (Matthew and Granger, 1926, p. 1; Berkey and Morris, 1927, p. 207), and the name "Irdin Manha" was restricted to the predominantly gray sandy clays, sands, and gravels comprising the upper 30 feet of the escarpment.

The restricted Irdin Manha beds are richly fossiliferous at the type locality, with most of the specimens coming from the bottom part of the section. Large collections were made in 1922 and 1923 from exposures

extending for a few miles on each side of the telegraph line and road (Morris [MS], 1923, book 3, p. 73, and several stratigraphic sections in that book). The specimens collected in 1922 are labeled "23 miles south of Iren Dabasu," or "Irdin Manha bench"; the 1923 collections, "Telegraph Line Camp."

The only fossils described from the Arshanto beds are the remains of several individuals of the lophialetid tapiroid *Schlosseria magister*, found at the edge of a small basin about 6 miles northeast of the type Irdin Manha locality (see sketch map and notes in Morris [MS], 1923, book 3, pp. 87, 104–105; the *Schlosseria* quarry probably lies near the bluff marked "a" on p. 87, for the distance from it to Arshanto well is recorded as 3 miles on p. 104). Matthew and Granger (1926, p. 5) considered *Schlosseria magister* much more primitive than the Irdin Manha tapiroid *Lophialetes expeditus* and therefore suggested that the Arshanto beds were possibly middle or early Eocene in age. I find *Schlosseria* similar enough to *Lophialetes* to indicate only a very slightly older age, possible early late Eocene, for the Arshanto beds.

In 1930, Teilhard and others made a small collection of mammal teeth and bones from beds called Irdin Manha at Arshanto Obo and 5 miles north of Arshanto Obo. Arshanto Obo is indicated on the sketch map in Granger ([MS], 1930, p. 18) and appears to be near the *Schlosseria* quarry of 1923. The lophialetid tapiroids in Teilhard's collection represent a form similar to *Schlosseria magister*, which suggests that they may have come from the Arshanto beds.

In 1923, Granger and Morris made a small collection, mainly of isolated teeth, from beds called Irdin Manha in an area about 25 miles east of Iren Dabasu (field no. 133; see section in Morris [MS], 1923, book 2, p. 43). Tapiroids similar both to *Schlosseria magister* and *Lophialetes expeditus* are present in the collection. The bones were not found in place and could have come from more than one horizon.

About 15 miles northwest of the Irdin Manha escarpment, a few miles south of Iren Dabasu, what appears to be the equivalent of the Irdin Manha Formation is capped by 15 feet of a loosely cemented soft yellow gravel, to which Granger and Berkey (1922, p. 5) gave the name Houldjin beds (also called Houldjin gravels). Fragmentary Oligocene fossils occur in the lower part of this formation.

### CAMP MARGETTS AREA

On May 5, 1923, Granger and Morris made a small collection of fossils in an area about 25 miles south-southwest of Iren Dabasu, and about

18 miles west-southwest of the type Irдин Manha locality. The stratigraphic section at this locality, from bottom to top, includes gray clays at the base; 40 feet of barren red sandy clays; about 35 feet of gray clayey sandstone, with some pink layers; 30 feet of white to gray arkosic, concretionary sandstones and conglomerates; a thin locally present gray clay; and finally, capping the escarpment, 10 feet of yellow sand and gravel (Morris [MS], 1923, book 2, pp. 76–79). Most of the fossils were found in the white to gray sandstones, but some came from the gray and pink clayey sands; all were listed under field no. 147, and catalogued as coming from the Irдин Manha beds.

Seven years later, in 1930, the Central Asiatic Expeditions returned to this area, set up a base called Camp Margetts a few miles south of the original 1923 locality, and made large collections from scattered exposures as far as 10 miles from Camp Margetts (see fig. 1). The principal collecting localities include: Overnight Camp, 5 miles east of Camp Margetts; exposures at Camp Margetts and up to 1 mile west; 6 miles west of Camp Margetts, center of basin; 7 miles west of Camp Margetts; 7 miles southwest (235°) of Camp Margetts; and 10 miles southwest of Camp Margetts. Granger's 1930 field book (Record of Fossils) includes stratigraphic sections measured at Camp Margetts (p. 43), 7 miles west of Camp Margetts (p. 38), and 10 miles southwest of Camp Margetts (pp. 50–51). None of these sections agrees exactly with any other or with the section measured in 1923. The sections include up to 125 feet of red and gray clays (in a different color sequence at each locality), capped by up to 50 feet of yellow and gray sandstones. The sandstones are labeled "Houldjin" and the entire sequence of red and gray clays, "Irдин Manha." All the specimens collected in this area in 1923 (field no. 147, including A.M.N.H. No. 20161, the type of *Desmatotherium fissum*, and A.M.N.H. No. 20136, a large achaenodont molar fragment figured in Matthew and Granger, 1925, p. 6, fig. 7) are recorded as from the Irдин Manha beds, even though most were found in the sandstones. In the 1930 collections all specimens from the sandstones are recorded as from the Houldjin beds, and all those found in the red and gray shales as from the Irдин Manha beds. In the literature the terms "Irдин Manha" and "Houldjin" are used indiscriminately and without qualifying remarks for horizons both in the Camp Margetts area and at the respective type localities.

From Granger and Morris' field notes, stratigraphic sequences at the various localities in the Camp Margetts area do not appear similar enough to one another or to the type sections at the Houldjin and Irдин Manha escarpments to allow definite correlation on the basis of lithology.

If anything, the red and gray shales considered the Irdin Manha equivalent in the Camp Margetts area are lithologically more similar to the type Arshanto beds than to the type Irdin Manha. *Lophialetes expeditus* (characteristic of the type Irdin Manha beds), and a form similar to *Schlosseria magister* (otherwise known only from the Arshanto beds), are recorded as coming from Irdin Manha beds in the Camp Margetts area, and the two forms display a different type of preservation, which suggests that more than one faunal horizon may be represented in these beds. However, I do not believe that the faunas involved are at present well enough understood (especially the relationship of Arshanto to Irdin Manha) to allow precise correlation on the basis of faunal evidence alone. The complexity of stratigraphic and faunal relationships in the Camp Margetts area is further indicated by peculiar distributional patterns, such as the occurrence of the chalicothere *Grangeria gobiensis* only at the locality 6 miles west of Camp Margetts, and all but one of the specimens of the aberrant dinocerate *Gobiatherium mirificum* at the exposure 7 miles west of Camp Margetts. These occurrences suggest that more than one faunal zone is involved, but the difference may be ecological rather than chronological.

The available evidence thus suggests that the relationship between the beds called "Irdin Manha" in the Camp Margetts area and the type Irdin Manha beds is complex and not yet fully understood. The solution to this problem requires careful stratigraphic investigations in the critical areas and the collection of additional faunal samples with accurate stratigraphic data. At least until such is done, the terms "Irdin Manha" and "Houldjin" should be placed in quotation marks when strata in the Camp Margetts area are referred to, to indicate that correlation is still uncertain.

### SHARA MURUN REGION

Richly fossiliferous late Eocene and Oligocene beds are exposed in three main areas in the Shara Murun region: at Baron Sog Mesa and North Mesa, west of the Shara Murun River, and at East Mesa and the cliffs extending to the north, east of the Shara Murun River (see fig. 2). Fossils were first discovered in this region in 1922, at Ula Usu, on the west side of Baron Sog Mesa, and large collections were made at that locality in 1923 and 1925. The section at Ula Usu consists of hard red clays overlain by 200 to 300 feet of soft, predominantly gray clays, with brown, red, and purple layers in the bottom part (see section in Morris [MS], 1923, book 4, p. 59; and comments in Granger [MS], 1923,



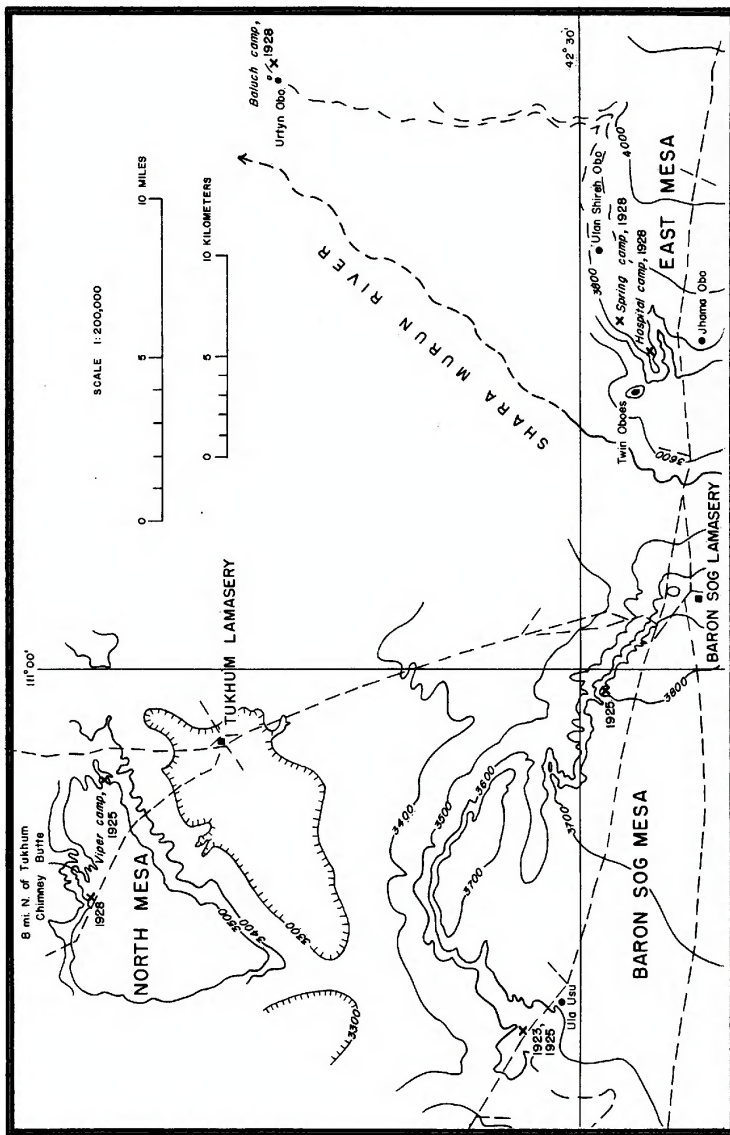


FIG. 2. Topographic map of the Shara Murun region of Inner Mongolia, showing camp sites (marked by an X) and collecting localities of the Central Asiatic Expeditions of the American Museum of Natural History. Contour interval is 100 feet. Topographic base map taken from sheet no. 7 of unpublished route maps of the Central Asiatic Expedition of 1925.

pp. 28–29). An abundant late Eocene fauna, younger than that at Irдин Manha, was found in the gray part of the soft multicolored clays, which were named the Shara Murun Formation (name first used without description in Berkey and Granger, 1923, p. 15; first described in Berkey and Morris, 1927, p. 362). The hard red clays at the base of the section are sparsely fossiliferous. They were at first called the “lower red beds” or Arshanto beds (Matthew and Granger, 1926, pp. 4–5), but later named the Tukhum Formation (Berkey and Morris, 1927, p. 359). The only fossil described from the Tukhum beds is A.M.N.H. No. 20299, the type and sole specimen of the rhinocerotoid *Teilhardia pretiosa*. Several undescribed specimens, including at least five individuals of *Lophialetes* cf. *L. expeditus* (A.M.N.H. Nos. 22091–22095), a rhinocerotoid upper premolar, and a small carnivore calcaneum, are recorded as coming from the “lower red beds” at Ula Usu, which presumably means the Tukhum beds. However, it is not clear from Morris’ section ([MS], 1923, book 4, p. 59) whether all the lower red clays were placed in the Tukhum Formation, or whether some are included in the basal part of the Shara Murun Formation. If the latter is the case, the Shara Murun beds might include more than one faunal zone, since *Lophialetes* is characteristic of the Irдин Manha fauna, which is older than the Shara Murun fauna.

In the northern and eastern parts of Baron Sog Mesa light-colored clays of the Shara Murun Formation are overlain by a red clay unit attaining a maximum thickness of 50 feet, named the Ulan Gochu Formation (Osborn, 1929, p. 3; Berkey, Granger, and Morris, 1929, p. 11; section in Morris [MS], 1925, book 8, p. 93). In 1925 a small collection of early Oligocene mammals was made from the Ulan Gochu beds (also called “upper red beds” or “upper red stratum”), 4 to 8 miles north of Baron Sog Lamasery, along the northeastern face of Baron Sog Mesa.

At the eastern edge of Baron Sog Mesa the red Ulan Gochu beds are overlain by about 15 feet of light gray clays and sands, named the Baron Sog Formation (Osborn, 1929, p. 3; Berkey, Granger, and Morris, 1929, p. 11; section in Morris [MS], 1925, book 8, p. 93). In 1925, Oligocene mammals were collected from the Baron Sog beds (also called “upper white stratum”) 4 to 8 miles north of the Baron Sog Lamasery.

An idealized section through Baron Sog Mesa would include, from bottom to top, red beds (Tukhum Formation), over 200 feet of light varicolored clays, predominantly gray toward the top (Shara Murun), 50 feet of red clays (Ulan Gochu), and 15 to 20 feet of white clays and sands (Baron Sog beds).

At North Mesa, about 15 miles northeast of Ula Usu, Baron Sog Mesa,

there are exposed at least 150 feet of richly fossiliferous, multicolored, predominantly red clays which were named by Berkey, Granger, and Morris (1929, pp. 11–12) the Ulan Shireh beds (sections in Morris [MS], 1925, book 8, pp. 109, 111; and Granger [MS], 1928, pp. 2, 6). In 1925 large collections were made from the Ulan Shireh beds at exposures 4 and 8 miles north of Tukhum Lamasery (not to be confused with 4 and 8 miles north of Baron Sog Lamasery). At this time the Ulan Shireh beds were thought to be equivalent to the Shara Murun beds, and the specimens are recorded in the 1925 field book as coming from the latter formation. The camp 4 miles north of Tukhum was called “Viper Camp.” In 1928, additional large collections were obtained from the Ulan Shireh beds at the exposure 8 miles north of Tukhum, which in 1928 was called “Chimney Butte.” A rich quarry named “Buckshot’s Quarry” yielded many specimens at Chimney Butte. After the 1928 field season Granger came to the conclusion that the Ulan Shireh beds at North Mesa were older than the Shara Murun beds and probably equivalent to the sparsely fossiliferous Tukhum beds exposed 15 miles to the southwest at Baron Sog Mesa (see later notes inserted by Granger [MS] in his 1925 [p. 66] and 1928 [p. 3] field books). This correlation is supported by paleontological evidence: the lophialetid tapiroids from the lower red beds at Ula Usu (A.M.N.H. Nos. 22091–22095) are identical to those in the Ulan Shireh fauna, which is extremely similar to that at Irdin Manha and older than the Shara Murun fauna. However, since the Tukhum fauna is so poorly known and since nothing like *Teilhardia* has been found in the Ulan Shireh beds, I think that for the present both names should be retained.

In 1928 large collections were made from late Eocene and Oligocene sediments exposed east of the Shara Murun River. At East Mesa, 10 to 15 miles east of the Ulan Gochu and Baron Sog localities on Baron Sog Mesa and about 7 miles east of Baron Sog Lamasery, the main camp was called “Dahser Hai,” or “Hospital Camp,” and the principal collecting localities referred to are Twin Oboes, at the northwest corner of East Mesa; Jhama Obo, a few miles southeast of Twin Oboes; and Spring Camp, about 3 miles east of Twin Oboes (see fig. 2). The stratigraphic section at East Mesa, from bottom to top, includes at least 40 feet of red silty clays; 125 feet of light-colored conglomerates and gravels; 117 feet of gravels grading upward into gray and brown silty clays; 7 to 15 feet of red silty clays; and 12 feet of white gravel (Spock [MS], 1928, book 1, p. 63; identical section in Granger [MS], 1928, p. 18; section published in Osborn, 1929, p. 5, fig. 2, section 1). In Spock’s and Granger’s field books the lower red beds and light-colored conglomerate and clays are



labeled "Shara Murun beds," the upper red clays, "Ulan Gochu," and the gravel cap, "Baron Sog." However, a note inserted later in Granger's book ([MS], 1928, p. 19) states that the boundary between Shara Murun and Ulan Gochu beds at Twin Oboes and Jhama Obo was not determined and that many of the specimens labeled "Shara Murun" are really "Ulan Gochu." In Granger's field book "Ulan Gochu" was written in over "Shara Murun" for most of the specimens originally recorded as coming from the latter horizon. In Osborn's (*loc. cit.*) section at least some, and possibly all, of the 117 feet of gray and brown silty clays are included in the Ulan Gochu beds.

Additional collections were made at Urtyn Obo (also known as Baluch Camp), about 15 miles northeast of the East Mesa localities. The stratigraphic section at Urtyn Obo includes, from bottom to top, a bright red silt, called "Basal Red"; an unspecified thickness of gray silts, called "Basal Gray"; about 50 feet of pink silts, called "Lower Red"; about 65 feet of gray sands with a conglomerate and a concretionary layer near the top, called "Lower Gray"; 60 to 70 feet of brick-colored silts, called "Middle Red"; 30 to 40 feet of light-colored sands and gravels, called "Middle White"; 95 to 120 feet of brick-colored silts, called "Upper Red"; and, finally, capping the escarpment, 25 to 30 feet of cross-bedded, gray and orange sands and gravels (Spock [MS], 1928, book 2, pp. 107-109; section duplicated in Granger [MS], 1928, p. 41; section published in Osborn, 1929, p. 5, fig. 2, section 2). The highest unit, the gray and orange sands and gravels, was correlated with the Baron Sog beds. The boundary between the Ulan Gochu and Shara Murun, as at East Mesa, was not determined; it was thought to lie somewhere in the Lower Gray unit. The Basal Red was considered possibly equivalent to the Ulan Shireh or Tukhum beds. Granger ([MS], 1928, p. 40) considered the Middle Red at Urtyn Obo equivalent to the single red unit assigned to the Ulan Gochu at East Mesa, and the Middle Gray and Upper Red, additional Ulan Gochu sediments not present at East Mesa.

About 30 miles northeast of Urtyn Obo (road distance) a stratigraphic section similar to that at Urtyn Obo is exposed at Nom Khong Shireh, or Holy Mesa<sup>1</sup> (Spock [MS], 1928, book 3, p. 17; section also in Granger [MS], 1928, p. 57; section published in Osborn, 1929, p. 5, fig. 2, section 3). As at East Mesa and Urtyn Obo, the contact between Ulan Gochu and Shara Murun beds could not be determined.

The main difficulty in correlating the strata exposed at East Mesa,

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<sup>1</sup> Called Nomogen Ora by the 1959 Sino-Soviet Paleontological Expedition.

Urtyn Obo, and Nom Khong Shireh with the type Shara Murun and Ulan Gochu beds at Baron Sog Mesa is that the lithology of these beds is too variable to allow correlation on the basis of lithology alone. Granger realized this and, in a letter quoted by Osborn (1929, p. 4), stated that he used the name "Ulan Gochu" for strata with titanotheres and artiodactyls different from those that were found in the type Shara Murun beds. (It should be noted that in this usage the term "Ulan Gochu" refers to a faunal zone rather than a formation.)

The main problem in working out the stratigraphic sequence east of the Shara Murun River is the delimiting of the boundaries between the Ulan Shireh, Shara Murun, and Ulan Gochu beds. These apparently must be determined largely on paleontological evidence, but the relevant collections have not yet been completely studied, and the faunal successions are not well enough known to provide the necessary information. My study of the tapiroids suggests that at least some of the beds at Urtyn Obo called "Shara Murun" are probably actually older. This is indicated by two lophialetid tapiroids (A.M.N.H. Nos. 26138 and 26139) which are recorded as coming from Shara Murun beds at Urtyn Obo but which represent forms characteristic of the Ulan Shireh fauna. Also, one specimen of the tapiroid genus *Teleolophus* (A.M.N.H. No. 26063), recorded as coming from the base of the "Middle Red" (called "Ulan Gochu") at Urtyn Obo, represents a species more primitive than its closest relative in the Shara Murun fauna (*Deperetella cristata*). However, the Urtyn Obo form represents a new species not known from anywhere else and could possibly be a persistently primitive late survivor.

An additional problem, the magnitude of which cannot be evaluated at present, is the inaccuracy of stratigraphic data recorded for the specimens. The anterior part of a chalicothere maxilla is recorded as coming from the base of the "Upper Red" at Urtyn Obo (field no. 733) while the posterior part of the same maxilla, preserved with A.M.N.H. No. 26138, is recorded as from the "Middle White" (field no. 738). These records indicate that errors were made in the determining or recording of the horizon from which specimens came, possibly owing to drift of weathered-out material down the steep slopes on which they were collected.

It would thus appear that stratigraphic information for specimens collected at East Mesa, Urtyn Obo, and Nom Khong Shireh cannot be completely trusted. Specimens from beds called "Shara Murun" or "Ulan Gochu" at those localities are not necessarily the same age as the respective type faunas. Until the stratigraphic succession in the Shara Murun region is better understood, specimens from that area should be

studied segregated by locality, and considerable caution should be used in interpreting any stratigraphic information based on lithological correlation.

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